CLAIMS

1. A vapourised flow quenching reactor for producing a fine-powder from one or more reactant materials comprising

(1) first heat creating means selected from one of a DC plasma torch and RF plasma torch, said first heat creating means including

(i) a reactant stream inlet for at least one input material selected from at least one gas phase and at least one non gas phase material, said non gas phase material to be vapourised by said first heat creating means and

(ii) a reactant stream outlet

(2) a first reaction chamber to receive said gaseous reactant stream from said reactant stream outlet of said first heat creating means wherein in said first reaction chamber said mixing and/or reaction of said reactant stream occurs, said first reaction chamber including an outlet for said reactant stream

(3) a first convergent-divergent nozzle to receive via an inlet thereof said reactant stream from said outlet of said first reaction chamber to rapidly cool the reactant stream axially flowing there through, as a result of adiabatic and isentropic expansion of the reactant stream, said first convergent-divergent nozzle including an outlet for said reactant stream

(4) a second reaction chamber including

(i) a first inlet to receive said reactant stream of material from said outlet of said first convergent-divergent nozzle, and

(ii) a second inlet for delivery of a second reaction stream into said second reaction chamber, said second reaction stream having been generated by second heat creating means selected from one of a DC plasma torch and RF plasma torch, said second heat creating means including

(a) a reactant stream inlet for at least one input material selected from at least one gas phase and at least one non

gas phase material, said non gas phase material to be vapourised by said second heat creating means and

(b) a second reactant stream outlet to deliver said second reactant stream via said second inlet of said second reaction chamber, into said second reaction chamber, and

(iii) an outlet of said second reaction chamber

(5) a second convergent-divergent nozzle to receive via an inlet thereof said resultant reactant stream (resultant from said first and/or second reactant streams) from said outlet of said second reaction chamber to rapidly cool the resultant reactant stream axially flowing there through as a result of adiabatic and isentropic expansion of the resultant reactant stream, said second convergent-divergent nozzle including an outlet for said reactant stream

(6) a collection chamber to receive material from said outlet of said second convergent-divergent nozzle.

2. A vapourised flow quenching reactor as claimed in claim 1 wherein said second reaction chamber includes a third inlet to receive a non vapouried material.

3. A vapourised flow quenching reactor as claimed in claims 1 or 2 wherein said second reaction chamber includes a third inlet to receive a non vapouried material to be heated by said second heat creating means within said second reaction chamber.

4. A vapourised flow quenching reactor as claimed in any one of claims 1 to 4 wherein said second inlet to said second reaction chamber allows said second heat creating means to extend its heat source into said second reaction chamber to active by heating at least part of any non or partially activated material within said second reaction chamber other than that delivered into said second reaction chamber via said second inlet of said second reaction chamber for the purposes of allowing such material to subsequently react with other material introduced into said second reaction chamber via at least one of said first inlet and said second inlet of said second reaction chamber.

5. A vapourised flow quenching reactor as claimed in any one of claims 2 to 4 wherein said second inlet to said second reaction chamber allows said second heat creating means to extend its heat source into said second reaction chamber to active by heating at least part of any non or partially activated material within said second reaction chamber other than that delivered into said second reaction chamber via at least one of said second inlet and third inlet of said second reaction chamber for the purposes of allowing such material to subsequently react with other material introduced into said second reaction chamber via at least one of said first inlet and said second inlet and said third inlet of said second reaction chamber.

6. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said first heat creating means is a DC plasma torch.

7. A vapourised flow quenching reactor as claimed in any one of claims 1 to 5 wherein said first heat creating means is an RF plasma torch.

8. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said second heat creating means is an RF plasma torch.

9. A vapourised flow quenching reactor as claimed in any one of claims 1 to 7 wherein said second heat creating means is a DC plasma torch.

10. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein a collection chamber is positioned intermediate of the outlet of said first convergent-divergent and said first inlet of said second reaction chamber.

11. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said first inlet to said second reaction chamber is disposed in a manner to encourage a rotational flow to be established within said second reaction chamber by said first heat creating origination reactant stream to encourage mixing thereof with any second heat source originating reactant stream.

12. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein reactor can be operated in

i. a first mode wherein reactant flow through said first heat creating source is established and reactant flow through said second heat creating source is established, and

ii. a second mode wherein reactant flow through said first heat creating source is established and no reactant flow through said second heat creating source is established.

13. A vapourised flow quenching reactor as claimed in any one of claims 1 to 11 wherein reactor can be operated in

i. a first mode wherein reactant flow through said first heat creating source is established and reactant flow through said second heat creating source is established, and

ii. a third mode wherein no reactant flow through said first heat creating source is established and reactant flow through said second heat creating source is established..

14. A vapourised flow quenching reactor as claimed in any one of claims 2 to 11 wherein reactor can be operated in

i. a first mode wherein reactant flow through said first heat creating source is established and reactant flow originating from said second heat creating source is established, and

ii. a fourth mode wherein reactant flow through said first heat creating source is established and no reactant flow from said second heat creating source is established and material is delivered via said third inlet to said second reaction chamber.

15. A vapourised flow quenching reactor as claimed in any one of claims 2 to 11 wherein reactor can be operated in

i. a firth mode wherein reactant flow through said first heat creating source is established and reactant flow originating from said second heat creating source is established, and material is delivered via said third inlet to said second reaction chamber and

ii. a second mode wherein reactant flow through said first heat creating source is established and no reactant flow from said second heat creating source is established.

16. A vapourised flow quenching reactor as claimed in any one of claims 2 to 11 wherein reactor can be operated in

    i. a fifth mode wherein reactant flow through said first heat creating source is established and reactant flow originating from said second heat creating source is established, and material is delivered via said third inlet to said second reaction chamber and

    ii. a third mode wherein no reactant flow through said first heat creating source is established and reactant flow from said second heat creating source is established.

    iii. A vapourised flow quenching reactor as claimed in any one of claims 12 to 16 wherein reactor can be operated in any one or more combinations of said first, second, third, fourth and firths modes.

17. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said first divergent-convergent nozzle includes a means to inject a gas.

18. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said first divergent-convergent nozzle includes a means to inject a gas.

19. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said second divergent-convergent nozzle includes a means to inject a gas.

20. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said second divergent-convergent nozzle and said first divergent-convergent nozzle includes a means to inject a gas.

21. A vapourised flow quenching reactor as claimed in claims 18 or 20 wherein either or both said means to inject a gas is a means to inject said gas at a tangent to the axial direction of said nozzle in order to generate a rotational to said axial direction flow through said nozzle.

22. A vapourised flow quenching reactor as claimed in any one of claims 18 to 21 wherein either of both said means to inject a gas are proved to introduce said gas into said nozzle at the throat of said nozzle.

23. A vapourised flow quenching reactor as claimed in any one of claims 18 to 22 wherein said means to inject a gas includes a plurality of injection openings into said nozzle.

24. A vapourised flow quenching reactor as claimed in claim 2 wherein said third inlet is presented to said second reaction chamber to direct flow of material there through into the path of flow of the reactant stream from said second inlet.

25. A vapourised flow quenching reactor as claimed in claim 2 wherein said third inlet is presented to said second reaction chamber to direct flow of material there through, not into the path of flow of the reactant stream from said second inlet

26. A vapourised flow quenching reactor as claimed in claim 2 wherein said third inlet is presented to said second reaction chamber to allow the adjustability of said flow of material there through so allow said flow to be selectively directed either into or not into the path of flow of the reactant stream from said second inlet.

27. A vapourised flow quenching reactor as claimed in any one of claims 1 to 26 wherein the flow of reactant through said second convergent/divergent nozzle is below supersonic speeds.

28. A vapourised flow quenching reactor as claimed in any one of claims 1 to 27 wherein the flow of reactant through said first convergent/divergent nozzle is below supersonic speeds.

29. A vapourised flow quenching reactor as claimed in any one of the preceding claims wherein said at least one said torch both vapourises and ionises said input material.

30. A fine powder production process including a

a vapourised flow quenching reactor for producing a fine-powder from one or more reactant materials comprising

(1) first heat creating means selected from one of a DC plasma torch and RF plasma torch, said first heat creating means including

(i) a reactant stream inlet for at least one input material selected from at least one gas phase and at least one non gas phase material, said non gas phase material to be vapourised by said first heat creating means and

(ii) a reactant stream outlet

(2) a first reaction chamber to receive said gaseous reactant stream from said reactant stream outlet of said first heat creating means wherein in said first reaction chamber said mixing and/or reaction of said reactant stream occurs, said first reaction chamber including an outlet for said reactant stream

(3) a first convergent-divergent nozzle to receive via an inlet thereof said reactant stream from said outlet of said first reaction chamber to rapidly cool the reactant stream axially flowing there through, as a result of adiabatic and isentropic expansion of the reactant stream, said first convergent-divergent nozzle including an outlet for said reactant stream

(4) a second reaction chamber including

(i) a first inlet to receive said reactant stream of material from said outlet of said first convergent-divergent nozzle, and

(ii) a second inlet for delivery of a second reaction stream into said second reaction chamber, said second reaction stream having been generated by second heat creating means selected from one of a DC plasma torch and RF plasma torch, said second heat creating means including

(a) a reactant stream inlet for at least one input material selected from at least one gas phase and at least one non gas phase material, said non gas phase material to be vapourised by said second heat creating means and

(b) a second reactant stream outlet to deliver said second reactant stream via said second inlet of said second reaction chamber, into said second reaction chamber, and

(iii) an outlet of said second reaction chamber

(7) a second convergent-divergent nozzle to receive via an inlet thereof said resultant reactant stream (resultant from said first and/or second reactant streams) from said outlet of said second reaction chamber to rapidly cool the resultant reactant stream axially flowing there through as a result of adiabatic and isentropic expansion of the resultant reactant stream, said second convergent-divergent nozzle including an outlet for said reactant stream

(8) a collection chamber to receive material from said outlet of said second convergent-divergent nozzle

wherein said process has a mode of operation selected from any one of

i. a first mode wherein reactant flow through said first heat creating source is established and reactant flow through said second heat creating source is established, and

ii. a second mode wherein reactant flow through said first heat creating source is established and no reactant flow through said second heat creating source is established, and

iii. a third mode wherein no reactant flow through said first heat creating source is established and reactant flow from said second heat creating source is established.

31. A fine powder production process as claimed in claim 30 wherein said second reaction chamber includes a third inlet to receive a non vapourised material and wherein said including process may operate in a mode selected from anyone of said first, second and third modes and

i. a fourth mode wherein reactant flow through said first heat creating source is established and no reactant flow from said second heat creating source is established and material is delivered via said third inlet to said second reaction chamber.

32. A fine powder production process as claimed in 31 wherein said second reaction chamber includes a third inlet to receive a non vapourised material and

wherein said including process may operate in a mode selected from anyone of said first, second, third and fourth modes and

i. a firth mode wherein reactant flow through said first heat creating source is established and reactant flow originating from said second heat creating source is established, and material is delivered via said third inlet to said second reaction chamber.

33. A fine powder production process as claimed in any one of claims 30 to 32 wherein said first divergent-convergent nozzle includes a means to inject a gas injecting a gas to generate a rotational to the axial direction flow through said third nozzle.

34. A fine powder production process as claimed in any one of claims 30 to 33 wherein said second divergent-convergent nozzle includes a means to inject a gas to generate a rotational to the axial direction flow through said second nozzle.

35. A method of using a vapourised flow quenching reactor as claimed in claims 1 for forming a packaged powder said method comprising;

passing a vapourised material by said first heat creation means gaseous flow entrained compound or element from said first reaction chamber through said first convergent/divergent nozzle to create a nano particle powder material which is delivered via said first inlet of said second reaction chamber where said nano particles are surface reacted by said second heat creation means to allow the reaction of said nano particles with a material (herein after "packaging material") introduced into said reaction chamber via said second inlet to become packaged by said packaging material where after said packaged nano particles are passed through said second convergent-divergent nozzle for collection in said collection chamber.

36. A method of using a vapourised flow quenching reactor as claimed in claim 2 for forming a packaged powder said method comprising;

passing a vapourised material by said first heat creation means gaseous flow entrained compound or element from said first reaction chamber through said first convergent/divergent nozzle to create a nano particle powder material which is

delivered via said first inlet of said second reaction chamber where said nano particles are surface reacted by said second heat creation means to allow the reaction of said nano particles with a material (herein after "packaging material") introduced into said reaction chamber via at least one of said second inlet and said third inlet to become packaged by said packaging material where after said packaged nano particles are passed through said second convergent-divergent nozzle for collection in said collection chamber.

37. A method of using a vapourised flow quenching reactor as claimed in claim 2 for forming an alloyed powder said method comprising;

passing at least two vapourised materials by said first heat creation means gaseous flow entrained compound or element from said first reaction chamber through said first convergent/divergent nozzle to create an alloyed nano particle powder material which is delivered via said first inlet of said second reaction chamber.

38. A method of forming a packaged powder using a vapourised flow quenching reactor as claimed in claims 1 said method comprising;

passing a vapourised material by said first heat creation means gaseous flow entrained compound or element from said first reaction chamber through said first convergent/divergent nozzle to create a nano particle powder material which is delivered via said first inlet of said second reaction chamber where said nano particles are surface reacted by said second heat creation means to allow the reaction of said nano particles with a material (herein after "packaging material") introduced into said reaction chamber via said second inlet to become packaged by said packaging material where after said packaged nano particles are passed through said second convergent-divergent nozzle for collection in said collection chamber.

39. A method of forming a packaged powder using a vapourised flow quenching reactor as claimed in claim 2 said method comprising;

passing a vapourised material by said first heat creation means gaseous flow entrained compound or element from said first reaction chamber through said first convergent/divergent nozzle to create a nano particle powder material which is

delivered via said first inlet of said second reaction chamber where said nano particles are surface reacted by said second heat creation means to allow the reaction of said nano particles with a material (herein after "packaging material") introduced into said reaction chamber via at least one of said second inlet and said third inlet to become packaged by said packaging material where after said packaged nano particles are passed through said second convergent-divergent nozzle for collection in said collection chamber.

40. A method of forming an alloyed powder using a vapourised flow quenching reactor as claimed in claim 2 said method comprising;

passing at least two vapourised materials by said first heat creation means gaseous flow entrained compound or element from said first reaction chamber through said first convergent/divergent nozzle to create an alloyed nano particle powder material which is delivered via said first inlet of said second reaction chamber.

41. A convergent-divergent nozzle for quenching the flow of a heated gas flow entrained vapourised material (whether an elemental material or of a compound) for the purposes of producing a nano sized particle containing powder as a consequence of the rapid quenching of said vapourised material passing through said convergent–divergent nozzle said convergent-divergent nozzle including a means to affect the flow path of said heated gas flow entrained vapourised material through said convergent said convergent-divergent nozzle which includes an means to inject a flow of gas (herein after "flow modifying gas") into the flow path of said heated gas flow entrained vapourised material upstream of the divergent portion of said convergent-divergent nozzle which is injected via at least one delivery opening at an angle having a tangential component to the axial direction of said convergent-divergent nozzle.

42. A convergent-divergent nozzle as claimed in claim 41 wherein said means to inject includes a plurality of delivery openings for injection of said flow modifying gas.

43. A convergent-divergent nozzle as claimed in claim 41 or claim 42 wherein said means to inject is able to adjust the angle of said tangential component of flow to the path of said heated gas flow entrained vapourised material.

44. A convergent-divergent nozzle as claimed in any one of claims 41 to 43 wherein said means to inject is injected via at least one opening of said nozzle into the flow path of said heated gas flow entrained vapourised material at the throat of said nozzle.

45. A convergent-divergent nozzle as claimed in any one of claims 41 to 43 wherein said nozzle is one for operating at sub supersonic speeds.